



W91321-04-C-0023

LOGANEnergy Corp.

Los Angeles AFB PEM Demonstration Project
Midterm Report

Proton Exchange Membrane (PEM) Fuel Cell Demonstration
Of Domestically Produced PEM Fuel Cells in Military Facilities

US Army Corps of Engineers
Engineer Research and Development Center
Construction Engineering Research Laboratory
Broad Agency Announcement CERL-BAA-FY03

Ft MacArthur Civil Engineering Office, LA Air Force Base, CA

6 March, 2006

Executive Summary

Under terms of its FY'04 DOD PEM Demonstration Contract with ERDC/CERL, LOGANEnergy has installed a Plug Power GenSys 5kWe Combined Heat and Power fuel cell power plant at Los Angeles AFB. The unit operates at a very visible location at Ft MacArthur Civil Engineering Headquarters, Building 56. It is electrically configured to provide grid parallel/grid independent service and also thermally integrated with the facility's hot water system. The purpose of this Mid-term report is to update the information provided in the initial project report with information on the current operating status and operating reliability of the PEM unit. At this point in the project, S/NB283 has achieved 93% operational availability.

Based on revised calculations incorporated in this report, fuel cell operations have cost LA AFB an additional \$409.00 in energy expense to date.

The LA AFB POC for this project is Eddie Wilson whose coordinates are:
eddie.wilson@losangeles.af.mil Telephone 310-363-0904

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Proposal – Proton Exchange Membrane (PEM) Fuel Cell Demonstration of Domestically Produced Residential PEM Fuel Cells in Military Facilities

1.0 Descriptive Title

LOGANEnergy Corp. Small Scale PEM 2004 Demonstration at Los Angeles AFB, CA.

2.0 Name, Address and Related Company Information

LOGANEnergy Corporation

1080 Holcomb Bridge Road
BLDG 100- 175
Roswell, GA 30076
(770) 650-6388

DUNS 01-562-6211
CAGE Code 09QC3
TIN 58-2292769

LOGANEnergy Corporation is a private Fuel Cell Energy Services company founded in 1994. LOGAN specializes in planning, developing, and maintaining fuel cell projects. In addition, the company works closely with manufacturers to implement their product commercialization strategies. Over the past decade, LOGAN has analyzed hundreds of fuel cell applications. The company has acquired technical skills and expertise by designing, installing and operating over 30 commercial and small-scale fuel cell projects totaling over 7 megawatts of power. These services have been provided to the Department of Defense, fuel cell manufacturers, utilities, and other commercial customers. Presently, LOGAN supports 30 PAFC and PEM fuel cell projects at 21 locations in 12 states, and has agreements to install 22 new projects in the US and the UK over the next 18 months.

3.0 Production Capability of the Manufacturer

Plug Power manufactures a line of PEM fuel cell products at its production facility in Latham, NY. The facility produces three lines of PEM products including the 5kW GenSys5C natural gas unit, the GenSys5P LP Gas unit, and the GenCor 5kW standby power system. The current facility has the capability of manufacturing 10,000 units annually. Plug will support this project by providing remote monitoring, telephonic field support, overnight parts supply, and customer support. These services are intended to enhance the reliability and performance of the unit and achieve the highest possible customer satisfaction. Vinny Cassala is the Plug Power point of contact for this project. His phone number is 518.782.7700 ex1228, and his email address is vincent_cassala@plugpower.com.

4.0 Principal Investigator(s)

Name	Chris Davis	Keith Spitznagel
Title	COO	Vice President Market Engagement
Company	LOGANEnergy Corp.	LOGANEnergy Corp.
Phone	770.650.6388 x 102	860.210.8050
Fax	770.650.7317	770.650.7317
Email	cdavis@loganenergy.com	kspitznagel@loganenergy.com

5.0 Authorized Negotiator(s)

Name	Chris Davis	Keith Spitznagel
Title	COO	Vice President Market Engagement
Company	LOGANEnergy Corp.	LOGANEnergy Corp.
Phone	770.650.6388 x 102	860.210.8050
Fax	770.650.7317	770.650.7317
Email	cdavis@loganenergy.com	kspitznagel@loganenergy.com

6.0 Past Relevant Performance Information

a) Contract: PC25 Fuel Cell Service and Maintenance Contract #X1237022

Merck & Company
Ms. Stephanie Chapman
Merck & Company
Bldg 53 Northside
Linden Ave. Gate
Linden, NJ 07036
(732) 594-1686

Contract: Four-year PC25 PM Services Maintenance Agreement.

In November 2002 Merck & Company issued a four-year contract to LOGAN to provide fuel cell service, maintenance, and operational support for one PC25C fuel cell installed at their Rahway, NJ plant. During the contract period the power plant has operated at 94% availability.

b) Contract: Plug Power Service and Maintenance Agreement to support one 5kWe GenSys 5C and one 5kWe GenSys 5P PEM power plant at NAS Patuxant River, MD.

Plug Power
Mr. Vincent Cassala
968 Albany Shaker Rd.
Latham, NY 12110
(518) 782-7700 ext 1228

LOGAN performed the start-up of both units, after Southern Maryland Electric Cooperative completed most of the installation work, and continues to provide service and maintenance during the period of performance.

- c) Contract: A Partners LLC Commercial Fuel Cell Project Design, Installation and 5-year service and maintenance agreement.

Contract # A Partners LLC, 12/31/01

Mr. Ron Allison
A Partners LLC
1171 Fulton Mall
Fresno, CA 93721
(559) 233-3262

On April 20, 2004 LOGAN completed the installation of three 600kWe PC25C CHP fuel cells in Fresno, CA. The fuel cells also provide low-grade waste heat at 140 degrees F that furnishes thermal energy to 98 water source heat pumps located throughout the 12-story building during the winter months.

7.0 Host Facility Information



Los Angeles AFB



Fort MacArthur Base Housing

Los Angeles Air Force Base is located within El Segundo city limits, the base is divided into two areas; Area A where most major units are located, and Area B which houses the 61 Air Base Group, the clinic, BX, and the commissary.

Space and Missile Systems Center (SMC) traces its origins to the Western Development Division created in July 1954. The organization's original mission was to develop ICBMs and the results are a proud legacy with the early Atlas, Thor, and Titan of the 50s, through the Minuteman of the 60s, to the Peacekeeper of the 80s. SMC has been the center of military satellite development since 1956. The Center has contributed to maintaining peace through programs such as early warning systems, meteorological, navigation and communications satellites to serve combat forces.

Space and Missile Systems Center, part of Air Force Materiel Command, is responsible for research, development, acquisition, on-orbit testing and sustainment of military space and

missile systems. In addition to managing Air Force space and missile programs, SMC participates in space programs conducted by other U.S. military services, government agencies and North Atlantic Treaty Organization allies. SMC responds to user needs by developing and acquiring space systems. After launch and check-out, SMC turns these systems over to the appropriate operating command. SMC also serves as the integrating center for the Strategic Defense Initiative within AFMC. It monitors progress in more than 70 Space Defense Initiative efforts throughout AFMC. SMC itself has direct management responsibility for more than half of these efforts.

Fort MacArthur is a former Army installation acquired by the Air Force in 1982. It is named in honor of Lt. Gen. Arthur MacArthur, father of Douglas MacArthur, who later commanded American forces in the Pacific during World War II. At present, Fort MacArthur serves as a residential community for personnel of the Air Force Space Division Based at El Segundo. Fort MacArthur, the actual site for the fuel cell installation, is in San Pedro, about 13 miles south of the main base.

8.0 Fuel Cell Installation

The following photos were taken at the LA AFB Civil Engineering Office, Building 56.



Figure 1 - Completed Installation

Figure 1 displays the GynSys5C unit placed in the fenced yard adjacent to the Civil Engineering Headquarters, Building 56. LOGAN technicians dug a trench to cover the thermal recovery tubing, natural gas supply piping, and electric conduit that runs between the unit and the building to protect the aesthetic appearance of the yard. Figures 3 - 5 show this process.



Figure 2 – Electrical connections and heat recovery connections at the unit.



Figure 3 – Trenching pathway to the facility



Figure 4 – Trenching detail at the fuel cell



Figure 5 - Detail of gas and thermal connections at fuel cell



Figure 6 – Photo of gas service meter at the site

In order to construct the project, a digging permit was issued by the base, and in addition LA AFB required LOGAN to enter into a separate indemnity agreement before work could commence. This was the first such permit that LOGAN had encountered in the CERL PEM demonstration plan. The project got underway in mid March 2005. The installation progressed according to plan with minimal inconvenience to the base or the host site and the unit had its first start on May 10 2005. However, DSL Ethernet service to the fuel cell router was not established until the end of May whereupon the unit became fully operational. While operating at a set point of 2.5 kW the unit consumes 35,000 scf/h natural gas and delivers approximately 7,800 Btu/h at 140 degrees F to the customer heat exchanger. Since its initial start and extending through February 2006, the unit has achieved 93% operational availability.

The line diagram pictured below in Figure 7, illustrates the electrical and mechanical interfaces between the fuel cell and the host facility.

LA AFB PEM Fuel Cell Installation One-Line Diagram

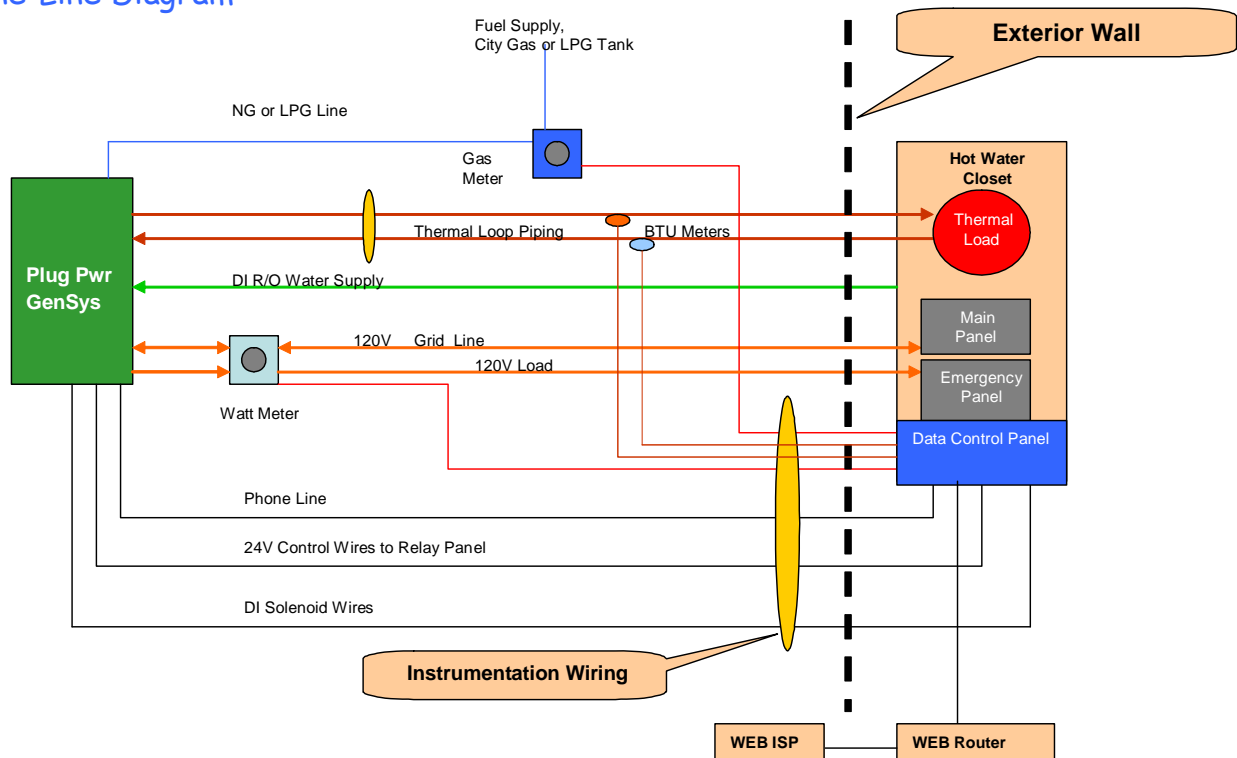


Figure 7 – Simple line diagram of the LA AFB fuel cell installation showing key utility interfaces required to operate the unit at the site.

9.0 Electrical System

The Plug Power GenSys 5C PEM fuel cell power plant provides both grid parallel and grid independent operating configurations for site power management. This capability is an important milestone in the development of the GenSys5 product and for the PEM Program itself, as it is a significant developmental step on the pathway to product commercialization. The unit has a power output of 110/120, VAC at 60 Hz and when necessary the voltage can be adjusted to 208vac or 220vac depending upon actual site conditions. The photo at right shows the electrical service panel in the basement of Building 56 where the fuel cell was electrically connected to the base utility grid. A new fuel cell emergency panel was installed adjacent to the existing panels and has several non-critical circuits attached to simulate the fuel cell's stand-by power application.



Figure 8 – Electrical panels in the host facility that distribute the fuel cell electrical power output

10.0 Thermal Recovery System



Figure 9 - Photo of hot water tank servicing the host facility

LOGAN employed a Heliodyne heat exchanger to capture fuel cell waste heat and transfer it into the facility's hot water heater, pictured in the photo at left, prior to installation. The Heliodyne is a looped coil within a coil design that provides double wall protection between the heat source and the heat sink. It was designed primarily for the solar heating industry, but has proved to be very adaptable to the fuel cell industry as well. The photos below show the Heliodyne mounted on an adjacent wall with its own pump, which circulates the storage tank in a counter flow against incoming hot water provided by the fuel cell's heat exchanger. While operating at a set point of 2.5 kWh, the fuel cell provides 7800 Btuh to the storage tank at approximately 140 degrees F.



Figure 10 – Close up of the Heliodyne heat exchanger and controls that transfer fuel cell waste heat into the hot water heater pictured above in Figure 9

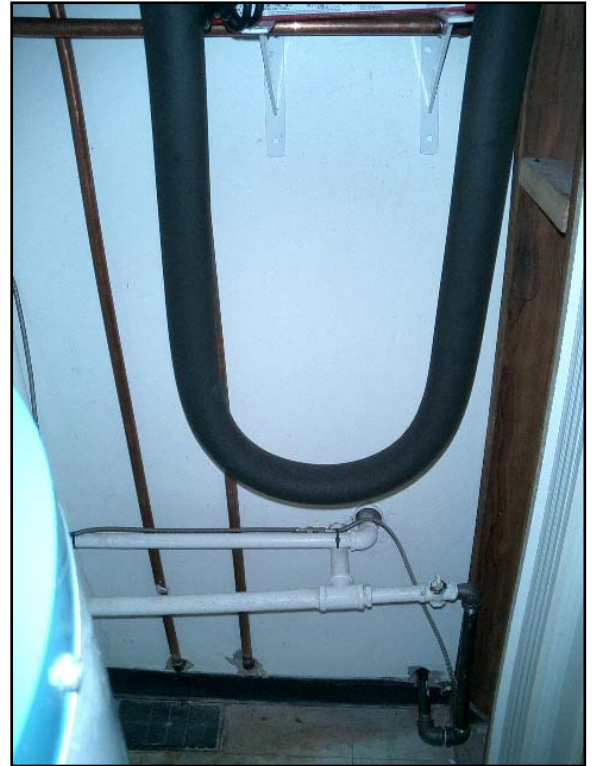


Figure 11 – Lower coil section of the Heliodyne heat exchanger

11.0 Data Acquisition System

LOGAN installed a Connected Energy Corporation web-based SCADA system that provides real-time monitoring, data collection, and data storage of the power plant's operations. The schematic drawing seen below describes the architecture of the CEC hardware that will support the project. The system provides a comprehensive data acquisition solution and also incorporates remote control, alarming, notification, and reporting functions. It also displays a number of fuel cell operating parameters on functional display screens including kWh, cell stack voltage, and water management, as well as external instrumentation inputs including Btus, fuel flow, and thermal loop temperatures. CEC's Operations Control Center in Rochester, New York collects, stores, displays, alarms, archives site data, and maintains connectivity by means of a Virtual Private Network that links the fuel cell to CEC's control center.

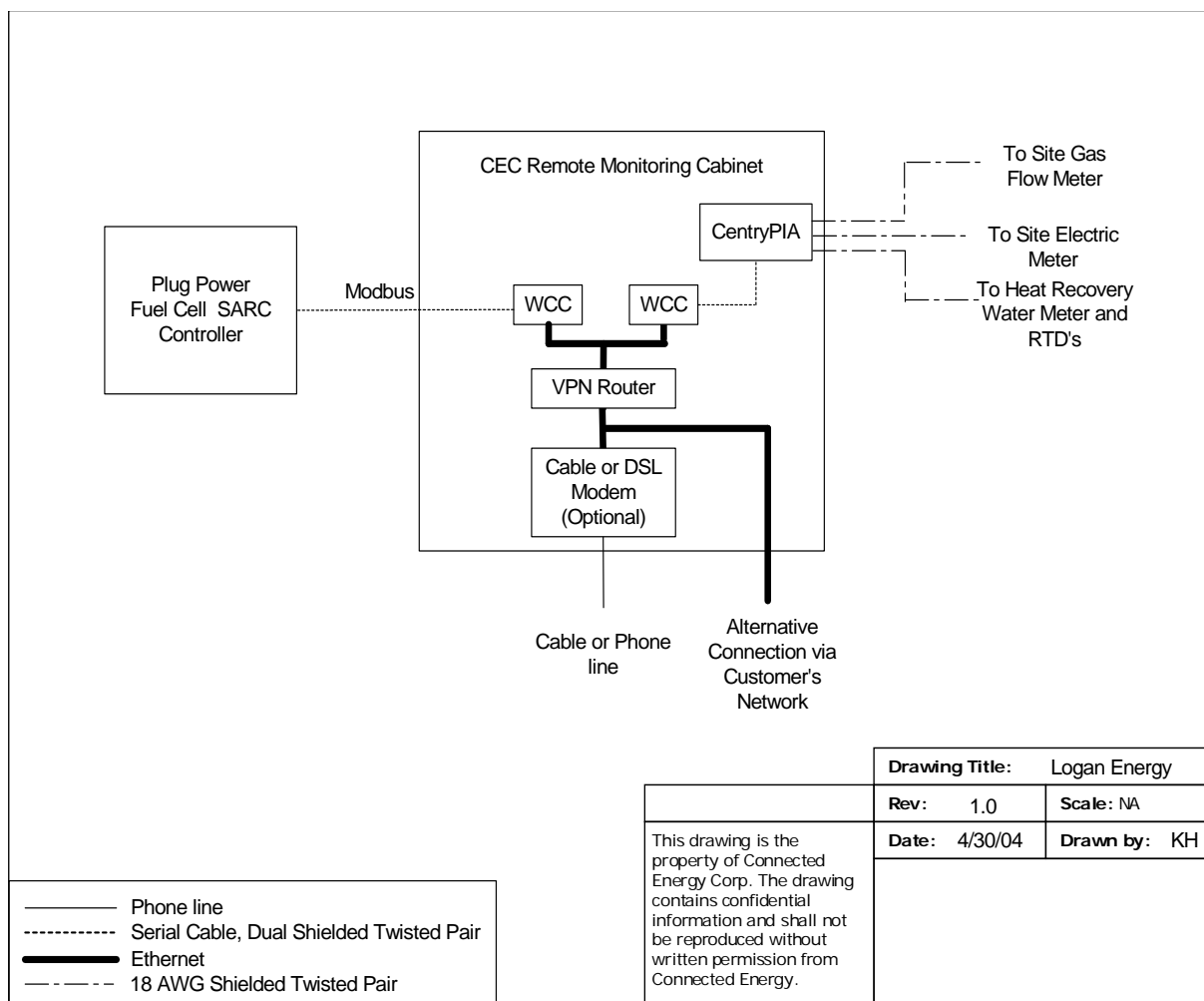


Figure 12 – CEC WEB enabled SCADA terminal hardware architecture

12.0 Fuel Supply System

LOGAN connected the fuel cell gas piping into the existing natural gas service line pictured in Figure 6, and installed a flow meter to calculate fuel cell usage as detailed in Paragraph 8.0. A regulator at the fuel cell gas inlet maintains the correct fuel cell operating pressure at 14 inches water column. While operating at a set point of 2.5kWh the Gensys5C consumes 35,000scfh of fuel.

13.0 Installation Costs

Las Angeles AFB, CA				
Project Utility Rates		Utility		
1) Water (per 1,000 gallons)	\$0.85	Southern California Water Company		
2) Utility (per KWH)	\$0.1100	Southern California Electric Company		
3) Natural Gas (per MCF)	\$9.55	Southern California Gas Company		
First Cost		Estimated	Actual	
Plug Power 5 kW GenSys5C		\$ 65,000.00	\$ 65,000.00	
Shipping		\$ 2,400.00	\$ 675.00	
Installation electrical		\$ 2,800.00	\$ 1,800.00	
Installation mechanical & thermal		\$ 6,300.00	\$ 4,200.00	
Watt Meter, Instrumentation, Web Package		\$ 1,285.00	\$ 11,301.00	
Site Prep, labor materials		\$ 825.00	\$ 367.00	
Technical Supervision/Start-up		\$ 4,500.00	\$ 9,039.00	
Total		\$ 83,110.00	\$ 92,382.00	
Assume Five Year Simple Payback		\$ 16,622.00	\$ 18,476.40	
Forecast Operating Expenses	Volume	\$/Hr	\$/ Yr	
Natural Gas Mcf/ hr @ 2.5kW	0.033	\$ 0.32	\$ 2,567.46	
Water Gallons per Year	14,016		\$ 11.91	
Total Annual Operating Cost			\$ 2,579.38	
Economic Summary				
Forecast Annual kWH		19710		
Annual Cost of Operating Power Plant	\$	0.131 kWH		
Credit Annual Thermal Recovery		(\$0.00010) kWH		
Project Net Operating Cost	\$	0.1308 kWH		
Displaced Utility cost	\$	0.1100 kWH		
Energy Savings (Cost)			(\$0.021) kWH	
Annual Energy Savings (Cost)			(\$409.35)	

Explanation of Calculations:

Actual First Cost Total is a *sum* of all the listed first cost components.

Assumed Five Year Simple Payback is the Estimated First Cost Total *divided by* 5 years.

Forecast Operating Expenses:

Natural gas usage in a fuel cell system set at 2.5 kW will consume 0.033 MCF per hour. The cost per hour is 0.033 Mcf per hour x the cost of natural gas to the site per MCF at \$11.00. The cost per year at \$2,484 is the cost per hour at \$0.32 x 8760 hours per year x 0.93. The 0.93 is for 93% availability thus far in the project.

Natural gas fuel cell systems set at 2.5 kW will consume 1.6 gallons of water per hour through the DI panel. The total volume of water consumed at 14,016 gallons per year is 1.6 gph x 8760 hours per year. The cost per year at \$11.91 is 14,016 gph x cost of water to the site at \$0.85 per 1000 gallons.

The Total Annual Operating Cost, \$2,579 is the *sum of* the cost per year for the natural gas and the cost per year for the water consumption.

Economic Summary:

The Forecast Annual kWh at 19,710 kWh is the product of the 2.5 kW set-point for the fuel cell system \times 8760 hours per year \times 0.9. The 0.9 is for 90% availability.

The Annual Cost of Operating the Power Plant at \$0.087 per kWh is the Total Annual Operating Cost at \$2.579 *divided by* the forecast annual kWh at 19,710 kWh.

The Credit Annual Thermal Recovery at -\$0.0001 is a credit to the operating cost expressed in kWh. As a credit, the value is expressed as a negative number.

The Project Net Operating Cost is the *sum* of the Annual Cost of Operating the Power Plant *plus* the Credit Annual Thermal Recovery.

The Displaced Utility Cost is the cost of electricity to LA AFB per kWh.

Energy Savings (cost) equals the Displaced Utility Cost *minus* the Project Net Operating Cost.

Annual Energy Savings (cost) equals the Energy Savings \times the Forecast Annual kWh.

14.0 Acceptance Test

An 8-hour acceptance test concluded on May 10, 2005 following the completion of all the commissioning and acceptance tasks listed in the Checklist attached below. It was the first successful start-up of the system. Please see Appendix Section 1 for documentation of the test done by the technician.


15.0 Other Pertinent Data

Appendix Section 2 posts two charts that were created using operational data retrieved from the Acquisition System described above in paragraph 11. The two displays are representative of the quality of information that is available for further analysis at LOGAN's PEM program web site. In order to access the site and view other data and information that is available, the reader may go to <https://www.enerview.com/EnerView/login.asp>. Then login as: logan.user and enter password: guest. Select the box labeled LA AFB. Then navigate the site or visit other LOGAN sites using the tool bars or html keys.

Appendix

Section 1 –Installation Checklist and Acceptance Test Report

Installation Report


 **INSTALLATION REPORT**

Serial Number

Installation Check List | **Commissioning Check List & Acceptance Test**

TASK	Initial	Date	Time (hrs)
Batteries Installed	MA	4/28/2005	1
Wiring Connections Inspected for Loose Connections and Tightness	MA	4/28/2005	3
Plumbing and Mechanical Connections Inspected for Tightness	MA	4/29/2005	1.5
Stack Installed	MA	4/28/2005	1.5
Stack Coolant Installed	MA	4/28/2005	0.7
Air Purged from Stack Coolant	MA	4/29/2005	0.5
Radiator Coolant Installed	MA	4/29/2005	0.7
Air Purged from Radiator Coolant	MA	4/27/2005	0.3
Inverter Power Cable Installed	MA	4/26/2005	2
Inverter Power Polarity Corrected	MA	4/28/2005	0.4
RS232 / Modem Cable Installed	MA	5/6/2005	0.5
Natural Gas Pipe Installed	MA	4/30/2005	12
DI Water / Heat Trace Installed	MA	4/30/2005	1
DI Panel Drain Installed	MA	4/26/2005	1
Verify Commissioning of DI Water Panel	MA	4/27/2005	2
System Drain Tubing Installed	MA	4/30/2005	1

Installation Report

 **INSTALLATION REPORT**

Serial Number

Installation Check List | **Commissioning Check List & Acceptance Test**

TASK	Initial	Date	Time (hrs)
Controls Powered Up and Communication OK	MA	4/27/2005	2.2
Inverter Setpoints Verified	MA	4/29/2005	0.3
Data Logging Setup (verify call out time with Plug Power Tech Support)	MA	4/27/2005	0.2
SARC Setpoints Verified	MA	4/28/2005	0.2
SARC System and Stack Name Correct	MA	5/6/2005	0.2
Modem Test Passed	MA	5/6/2005	0.2
Modem Phone Number with Area Code		<input type="text" value="1,310,519,1525"/>	
Start-UP Initiated	MA	4/28/2005	2
Coolant Leak Checked	MA	4/27/2005	0.2
Water Leak Checked	MA	4/28/2005	0.2
Flammable Gas Leak Checked	MA	4/28/2005	0.4
Data Logging to Central Computer	MA	5/6/2005	0.3
System Run for 8 Hours with No Failures	MA	5/2/2005	12
Verify Connectivity & Data Logging to Connected Energy System	MA	5/6/2005	0.3
Verify Thermal Heat Recovery Operational	MA	5/4/2005	2

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Section -2 – Representative Operating Data Charts

AC Power Output

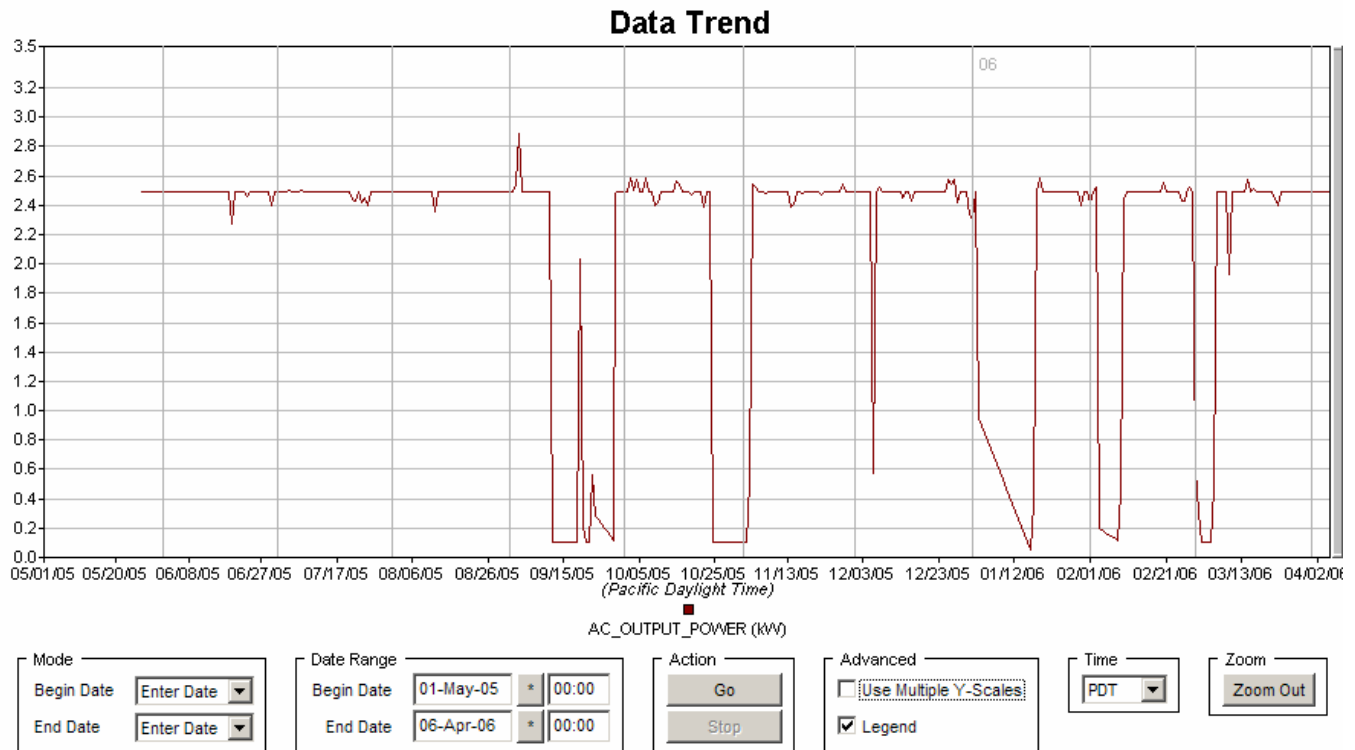


Figure 13 – Power Plant operating trend analysis of electrical output from first start on May 10, 2005 to April 6, 2006

Fuel cell cumulative fuel flow.

Data Trend

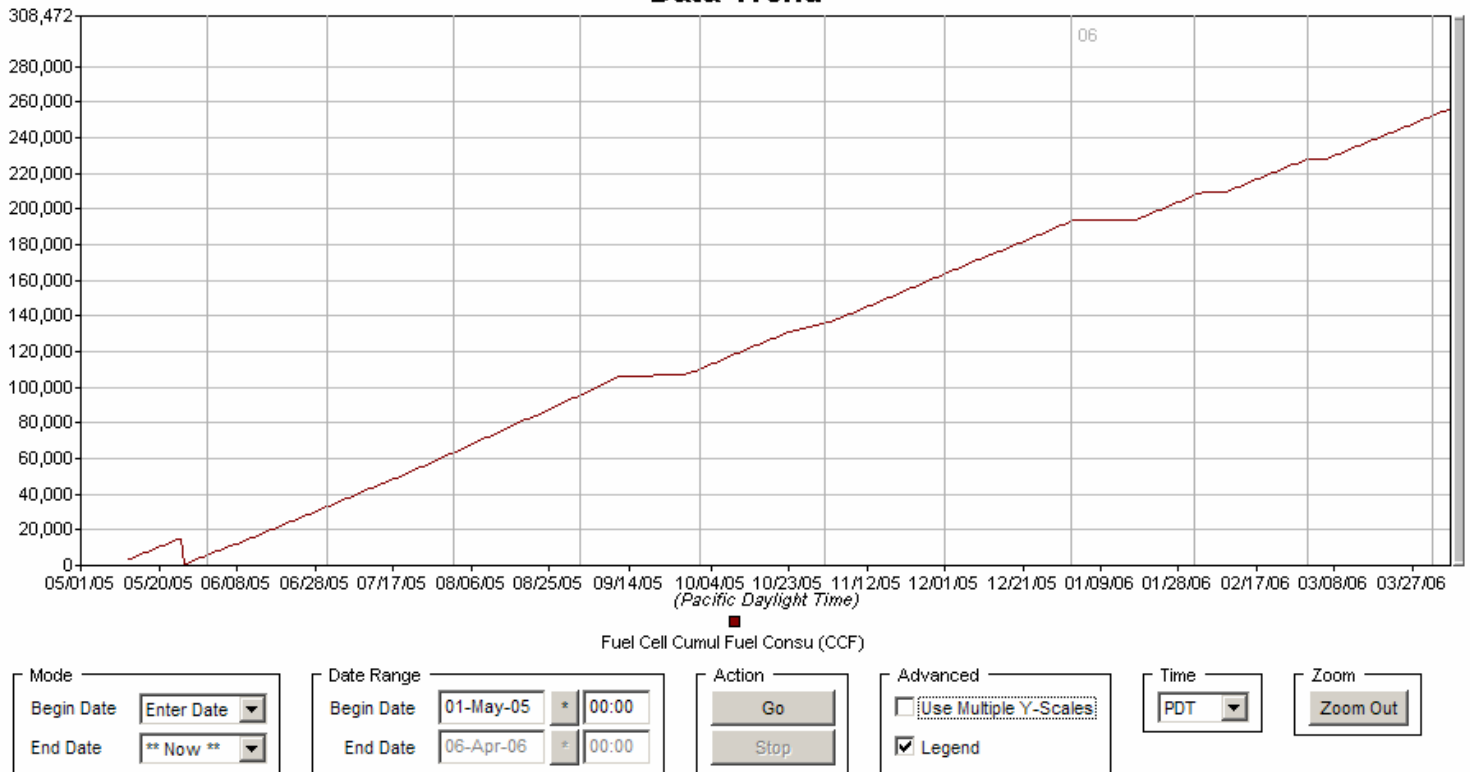


Figure 14 – Power Plant operating trend analysis of cumulative fuel consumption from first start on May 10, 2005 to April 6, 2006.